JPL Airborne Snow Observatory

Imaging snow water equivalent and snow albedo

Principal Investigator: Thomas H. Painter, JPL/Caltech
Co-Investigator: Frank Gehrke, CADWR

Outline

- MODIS remote sensing activities
- Snowmelt background
- Foundations of Airborne Snow Observatory
- ASO instrumentation
- ASO Demonstration Mission
- ASO snow-free campaign
- Future

MODSCAG

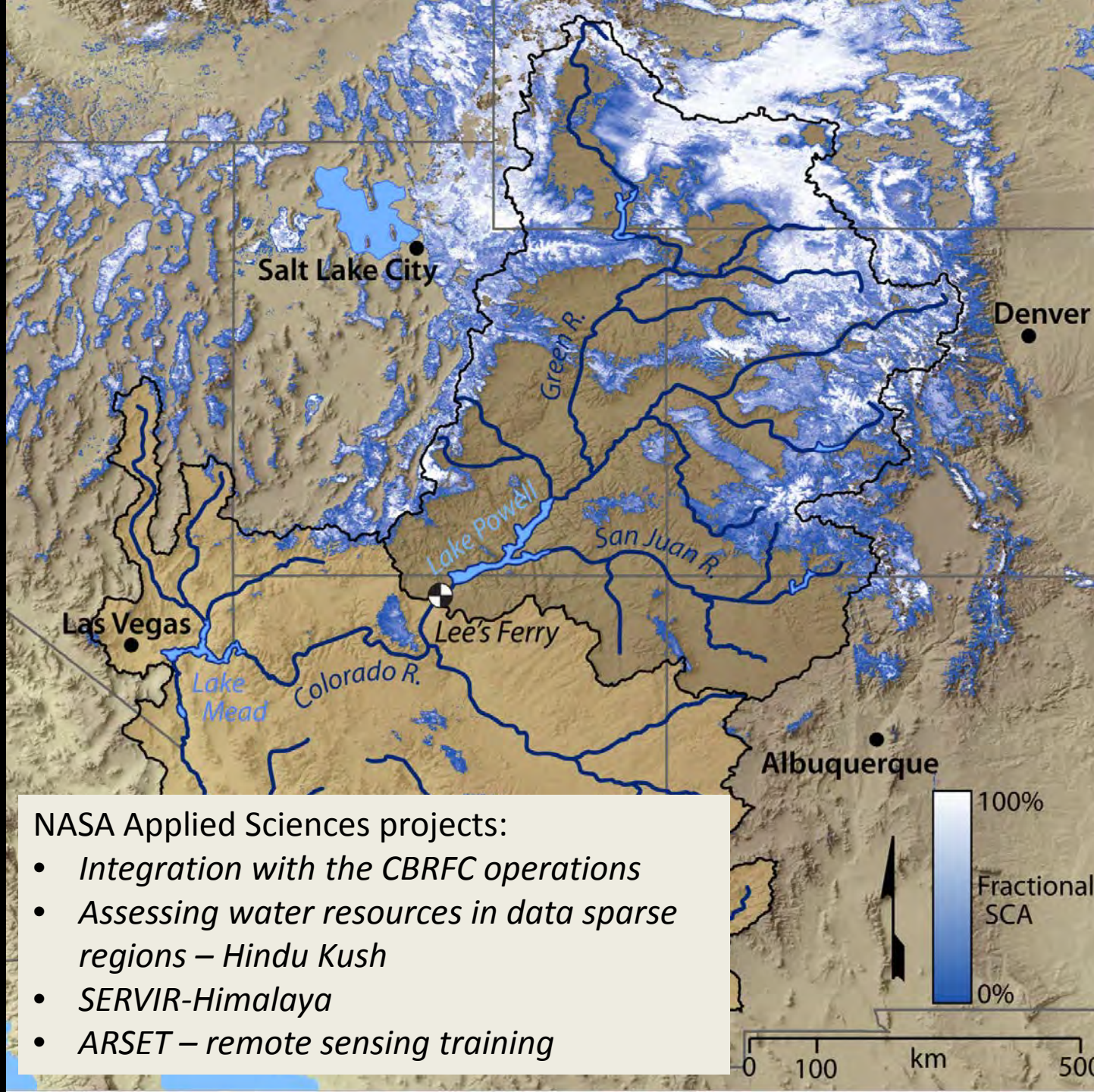
Fractional snow covered area

Painter et al 2009

NASA MODIS satellite
Near real-time product
Archived product to 2000

http://snow.jpl.nasa.gov

April 10, 2010



NASA Applied Sciences projects:

- *Integration with the CBRFC operations*
- *Assessing water resources in data sparse regions – Hindu Kush*
- *SERVIR-Himalaya*
- *ARSET – remote sensing training*

NASA IDS Project:
Integrated hydrologic response to extreme dust deposition to snow cover of the Colorado River Basin

Principal Investigator:
Thomas H. Painter

WATER RESOURCES RESEARCH, VOL. 48, W07521, doi:10.1029/2012WR011985, 2012

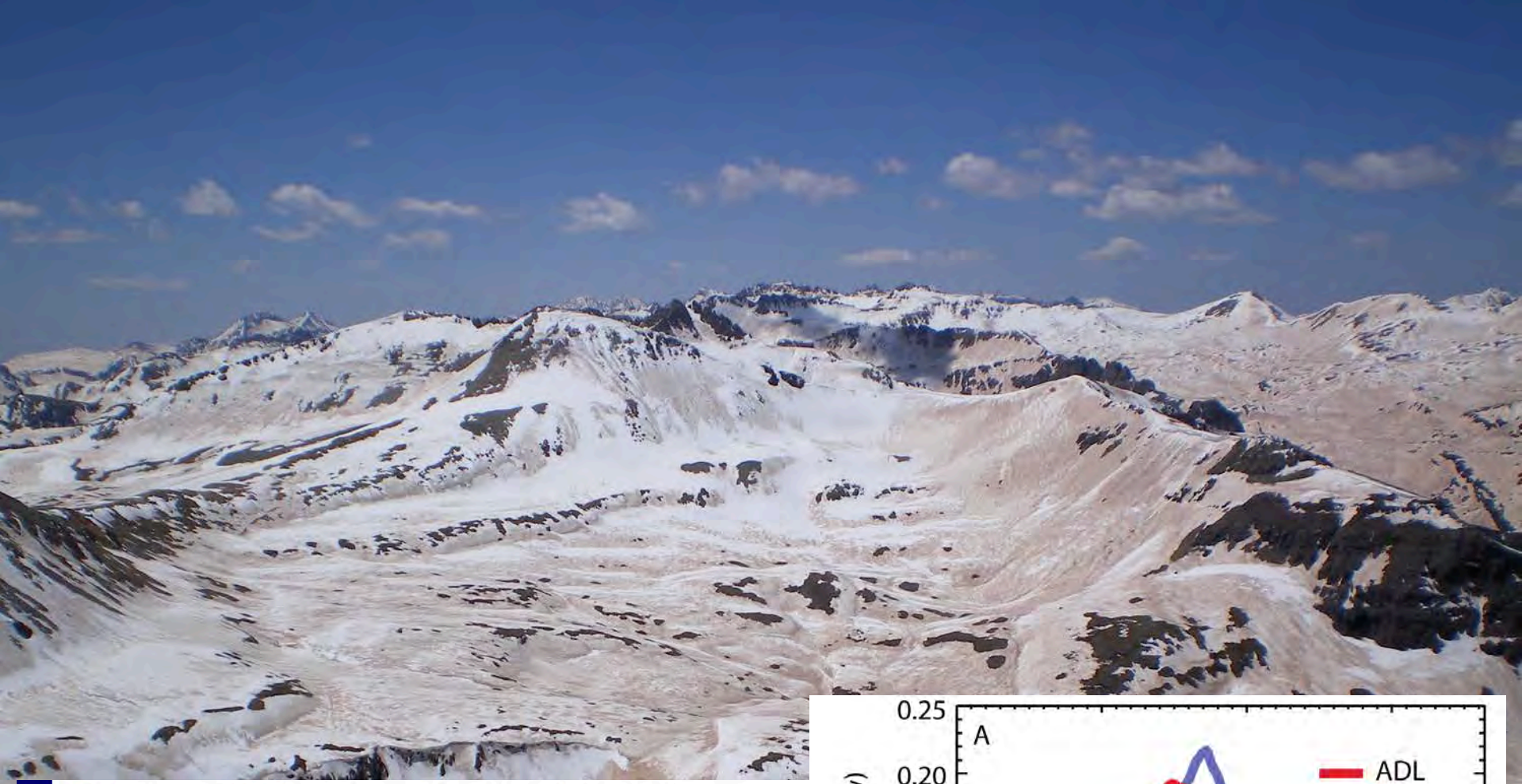
Dust radiative forcing in snow of the Upper Colorado River Basin: 1. A 6 year record of energy balance, radiation, and dust concentrations

Thomas H. Painter,[1,2,3] S. McKenzie Skiles,[2,3] Jeffrey S. Deems,[4,5] Ann C. Bryant,[6] and Christopher C. Landry[7]

WATER RESOURCES RESEARCH, VOL. 48, W07522, doi:10.1029/2012WR011986, 2012

Dust radiative forcing in snow of the Upper Colorado River Basin: 2. Interannual variability in radiative forcing and snowmelt rates

S. McKenzie Skiles,[1,2] Thomas H. Painter,[1,2,3] Jeffrey S. Deems,[4,5] Ann C. Bryant,[6] and Christopher C. Landry[7]



PNAS

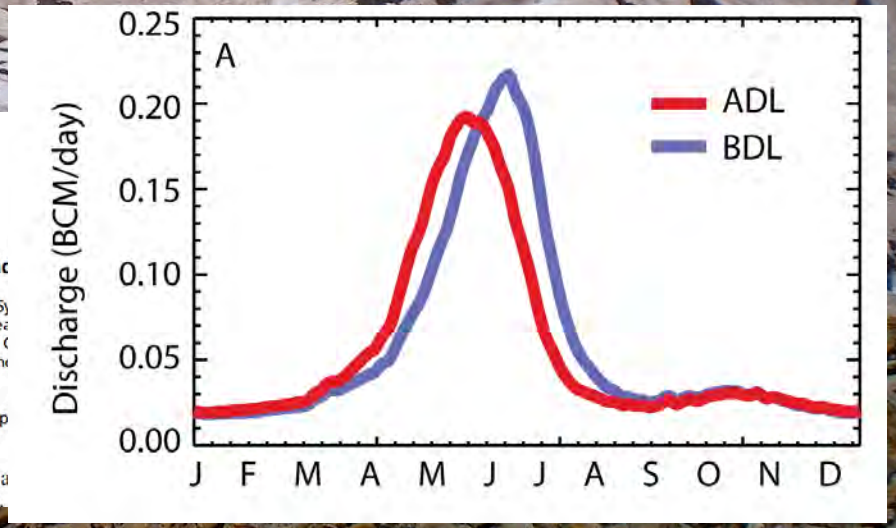
Response of Colorado River runoff to dust radiative forcing in snow

Thomas H. Painter[a,b,1], Jeffrey S. Deems[c,d], Jayne Belnap[e], Alan F. Hamlet[f], Christopher C. Lanc

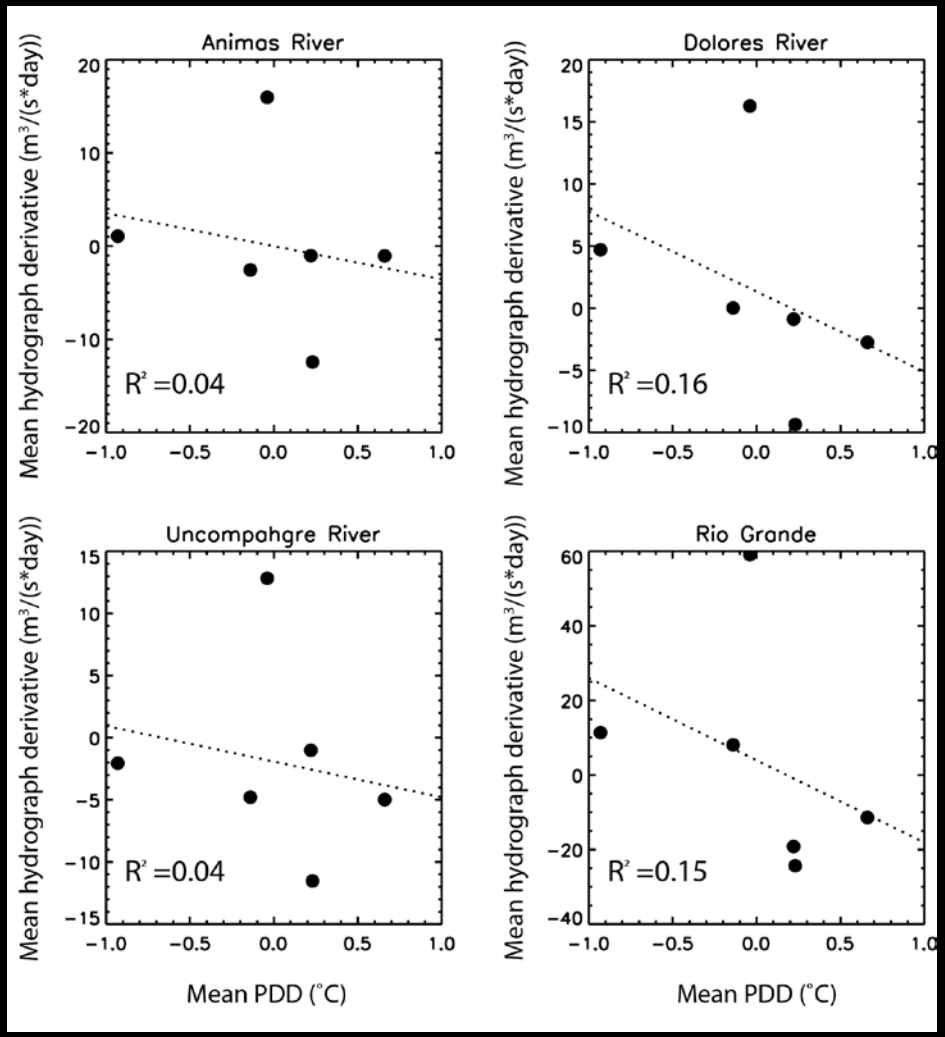
[a]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; [b]Joint Institute for Regional Earth Sy
University of California, Los Angeles, CA 90095; [c]National Snow and Ice Data Center, Boulder, CO 80309; [d]National Ocea
Administration Western Water Assessment, Boulder, CO 80309; [e]United States Geological Survey, Southwest Biological C
[f]University of Washington, Department of Civil and Environmental Engineering, Seattle, WA 98195; and [g]Center for Sn
Silverton, CO 81433

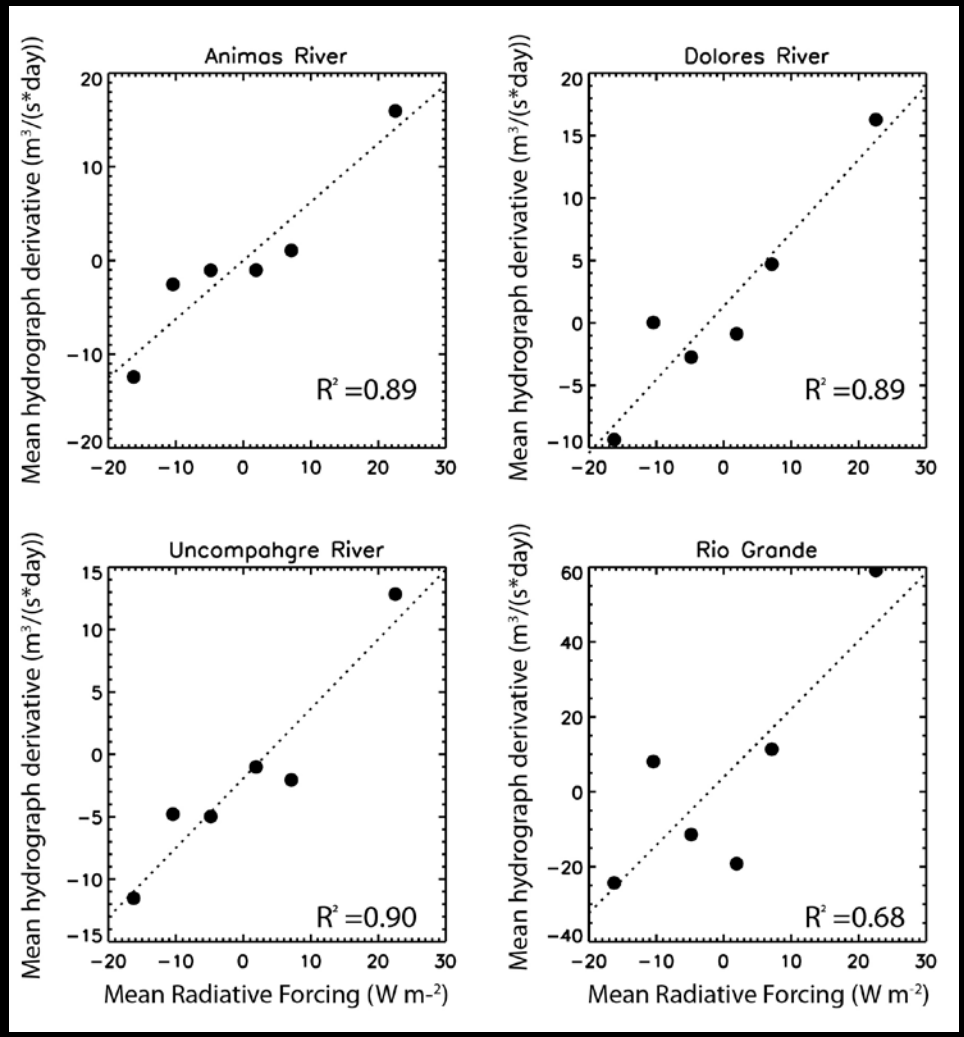
Edited by Peter H. Gleick, Pacific Institute for Studies in Development, Environment, and Security, Oakland, CA, and app
review November 12, 2009)

The waters of the Colorado River serve 27 million people in seven states and two countries but are overallocated by more than 10% through dust's direct absorption a accelerated snow metamorphism.



Explain steepness of rising limb





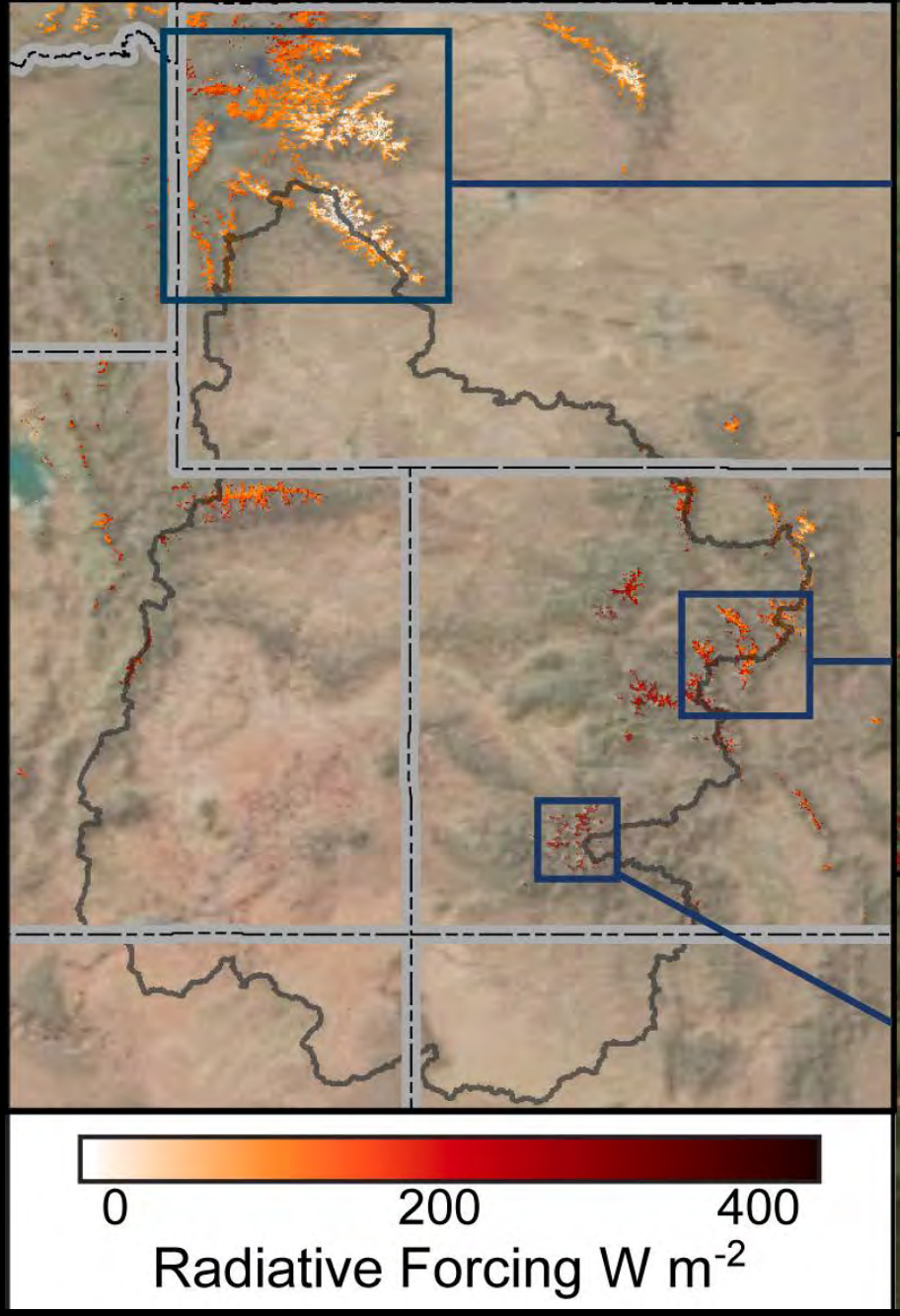
Painter et al (in preparation)

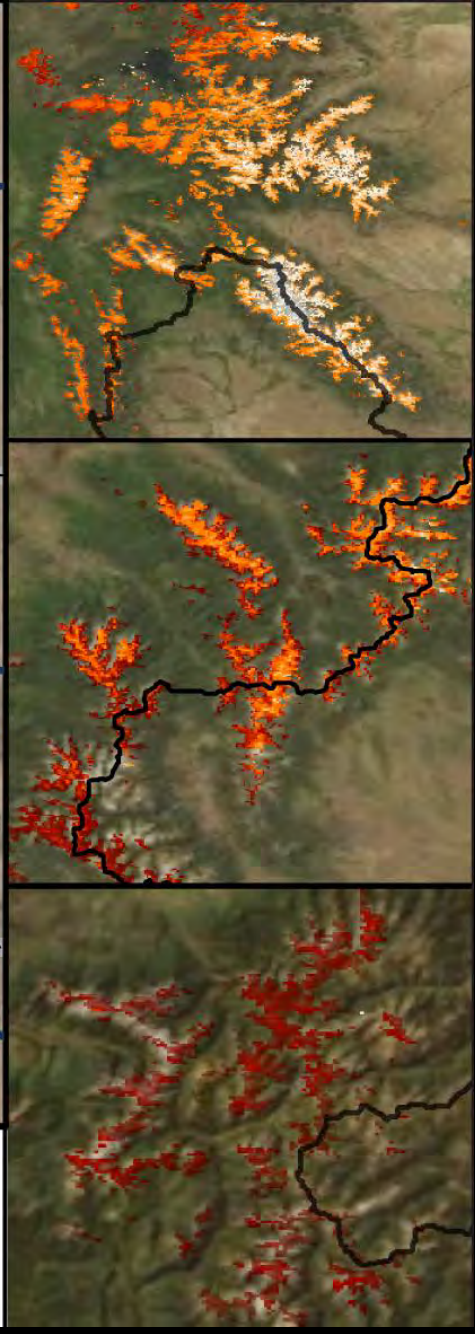
MODDRFS

Dust Radiative Forcing

NASA MODIS satellite
Near real-time product
Archived product to 2000

http://snow.jpl.nasa.gov



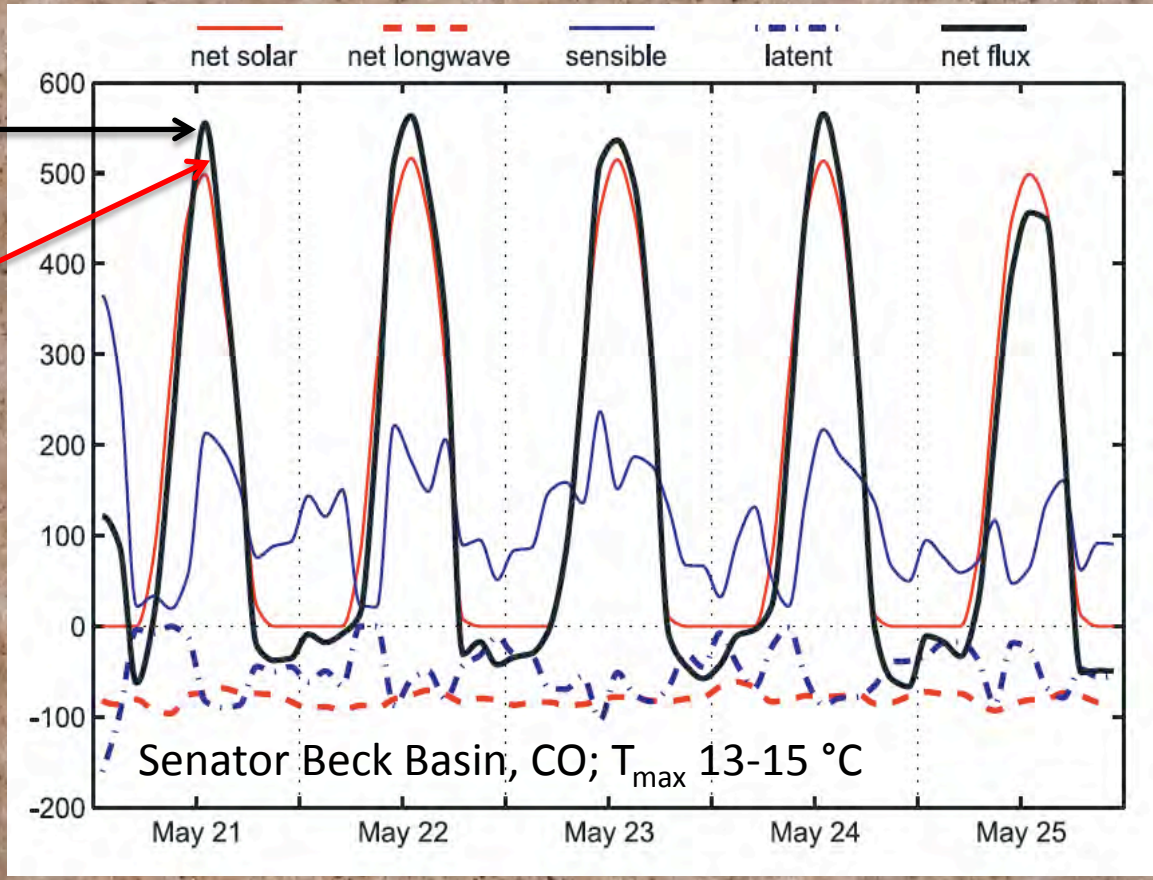


Painter et al 2012

What controls snowmelt?

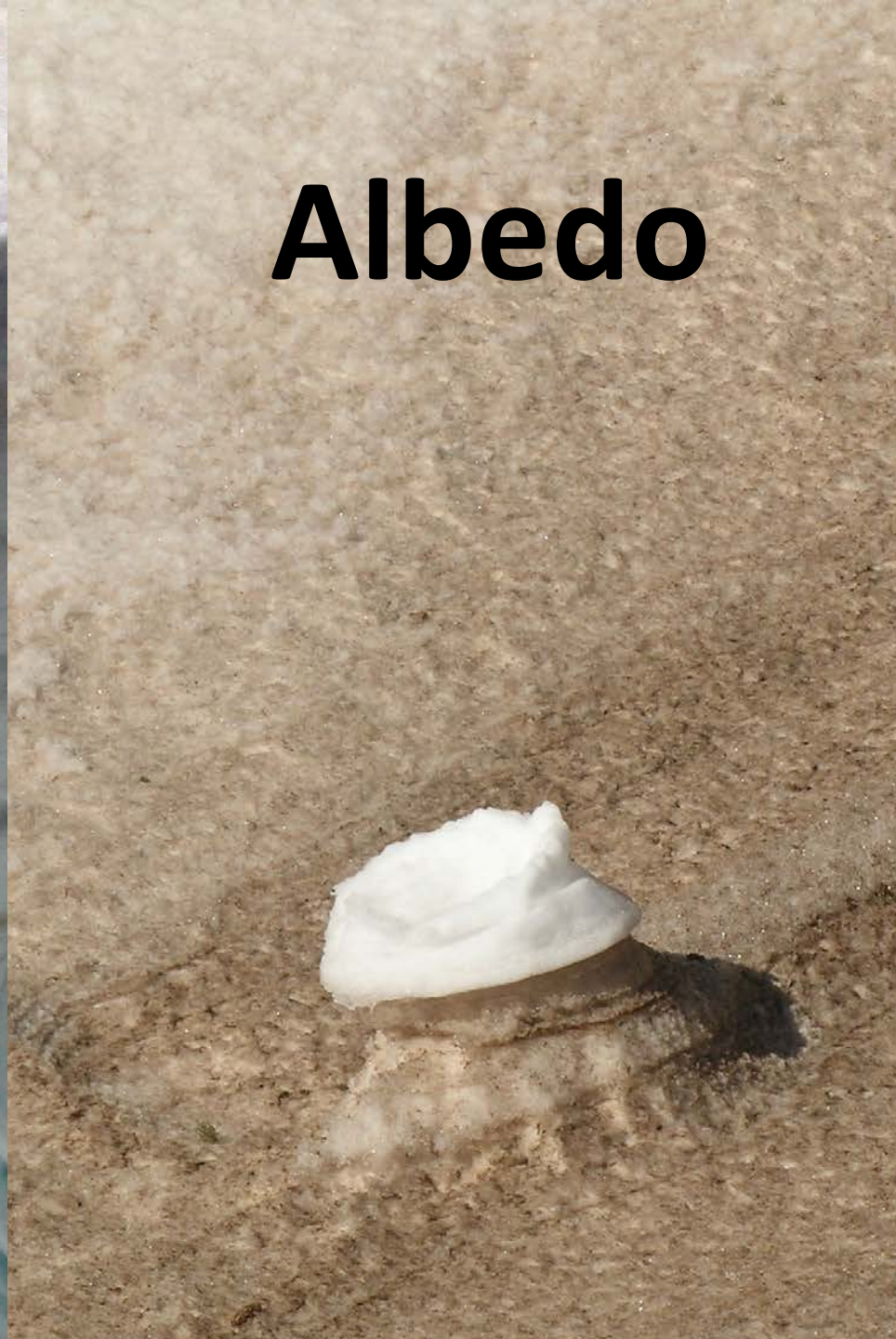
Energy for melting

Absorbed sunlight



Elk Range, Colorado River Basin, April 2009


SWE


Albedo

Manual measurement of SWE (snow water equivalent), started in the Sierra Nevada in 1910

Imaging Spectrometer
0.35-2.50 µm
4 m spatial resolution from 4000 AGL

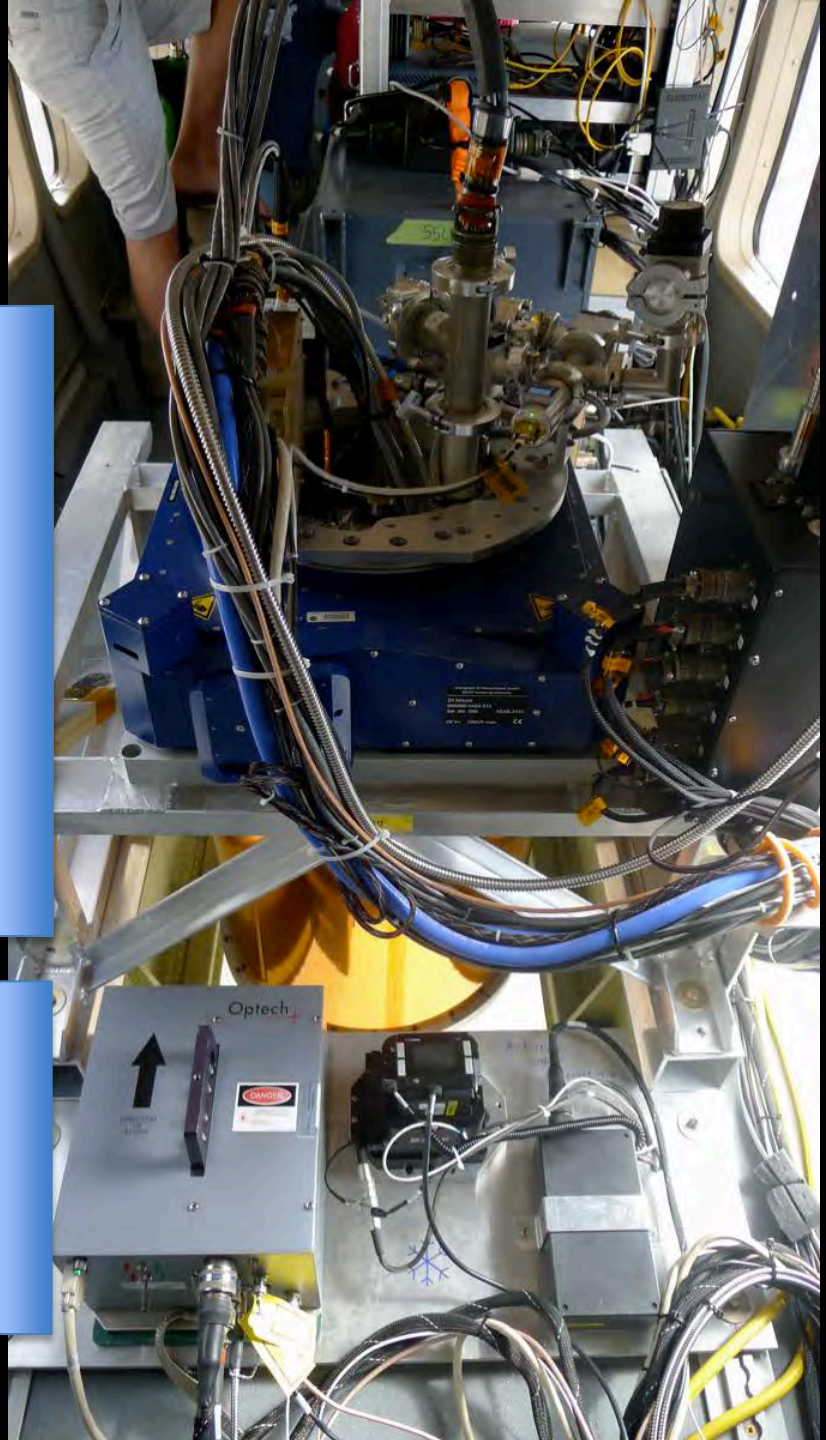
Albedo

Uncertainty < 2%

3D Scanning LiDAR
1064 nm
1 m spatial resolution

SWE

Uncertainty < 5 cm



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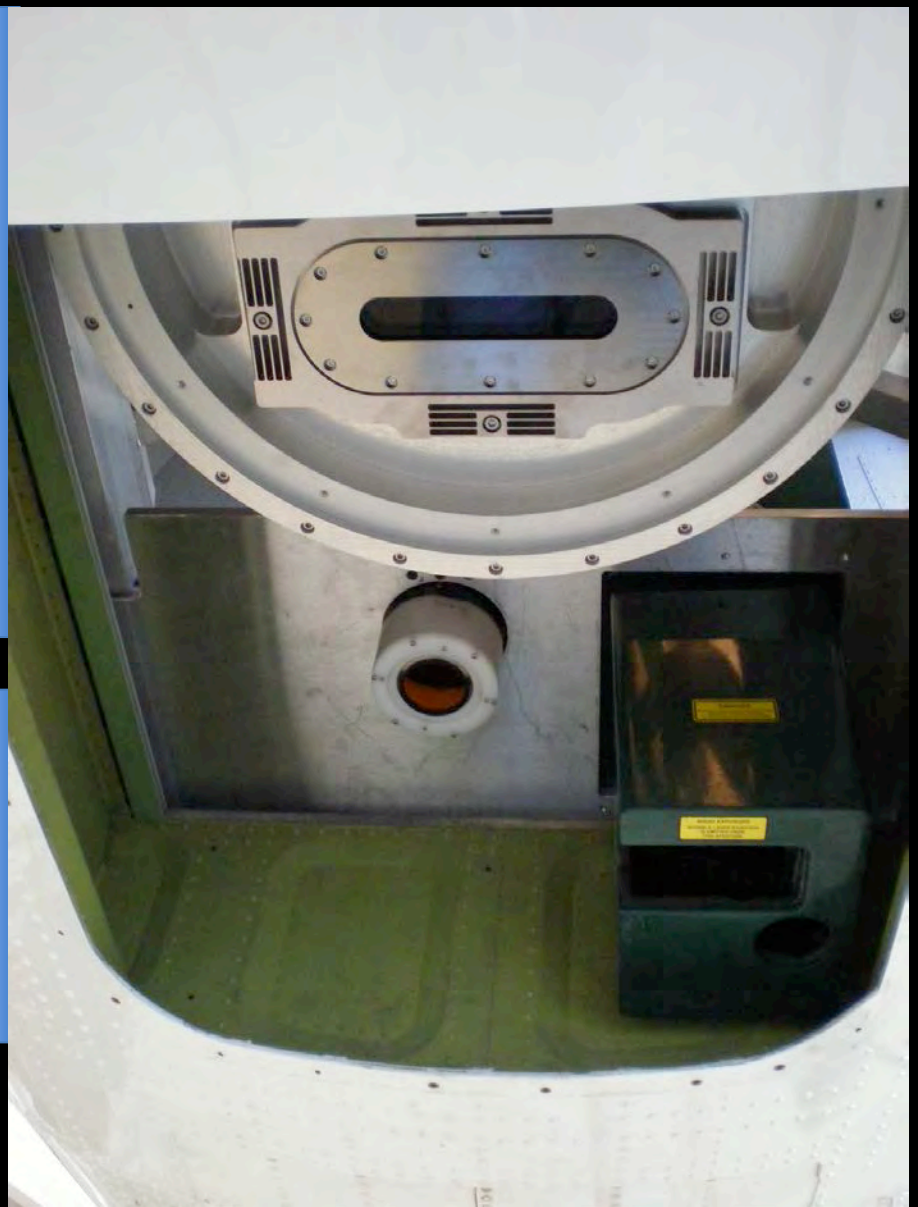
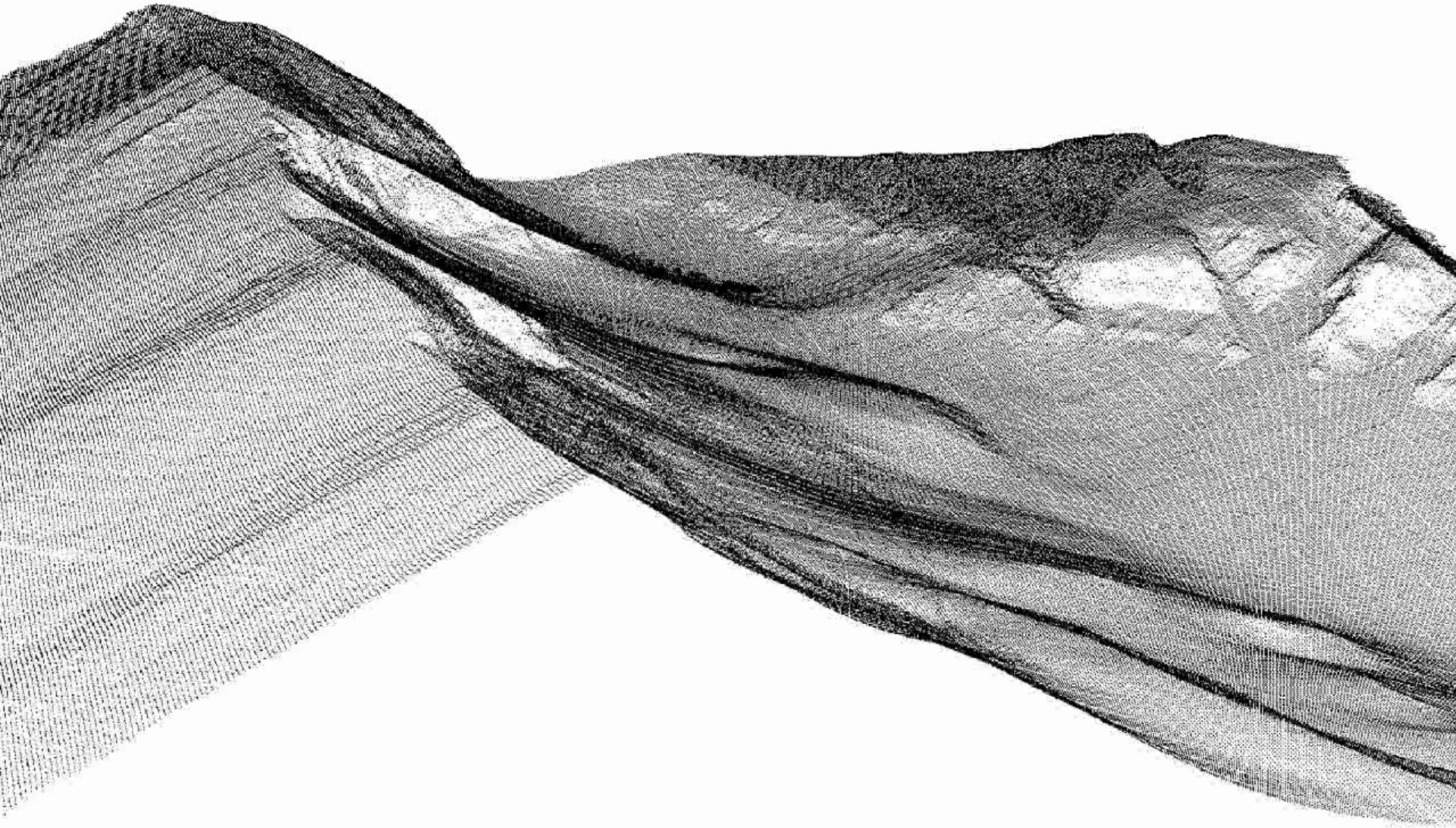
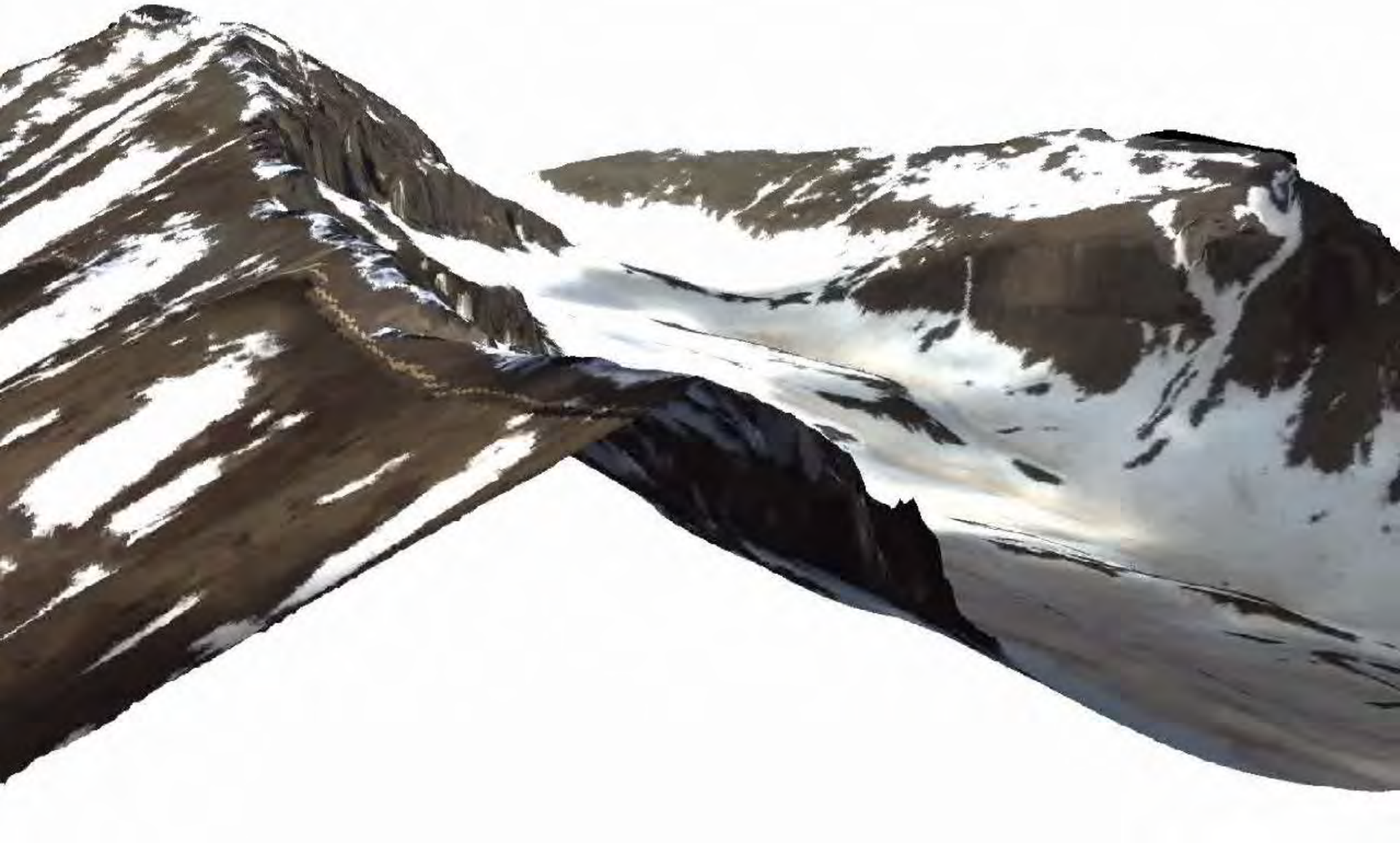


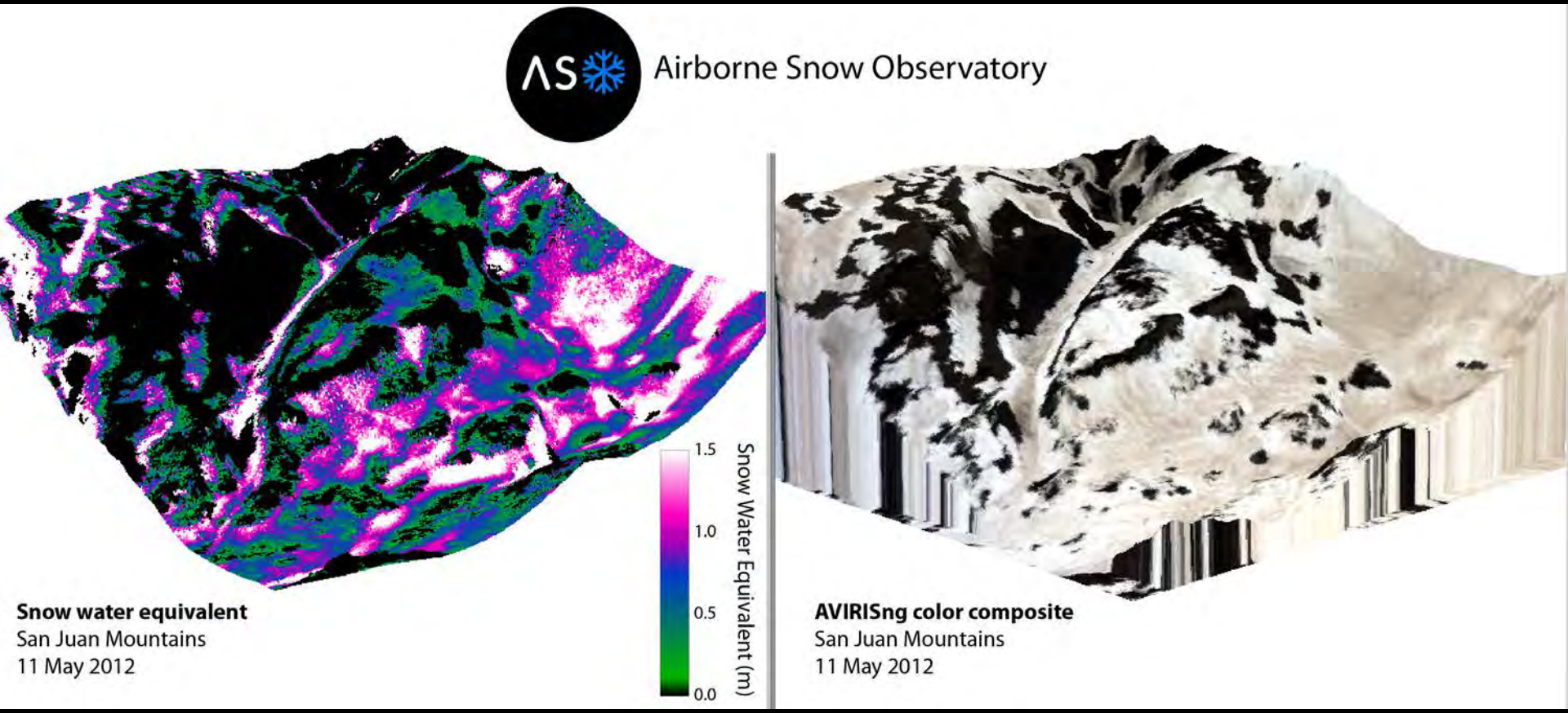
ASO Demonstration Mission

Milestone	Date
Data System Check (NEON data)	Jun 2012
Spectrometer/LiDAR integration/test flights	Jul 23-27 2012
Snow-free acquisitions for LiDAR baseline	Aug 1-10 2012
Snow-on acquisitions of ASO (weekly) * sub-24 hour latency on product delivery	Mar 15-Jul 15 2013

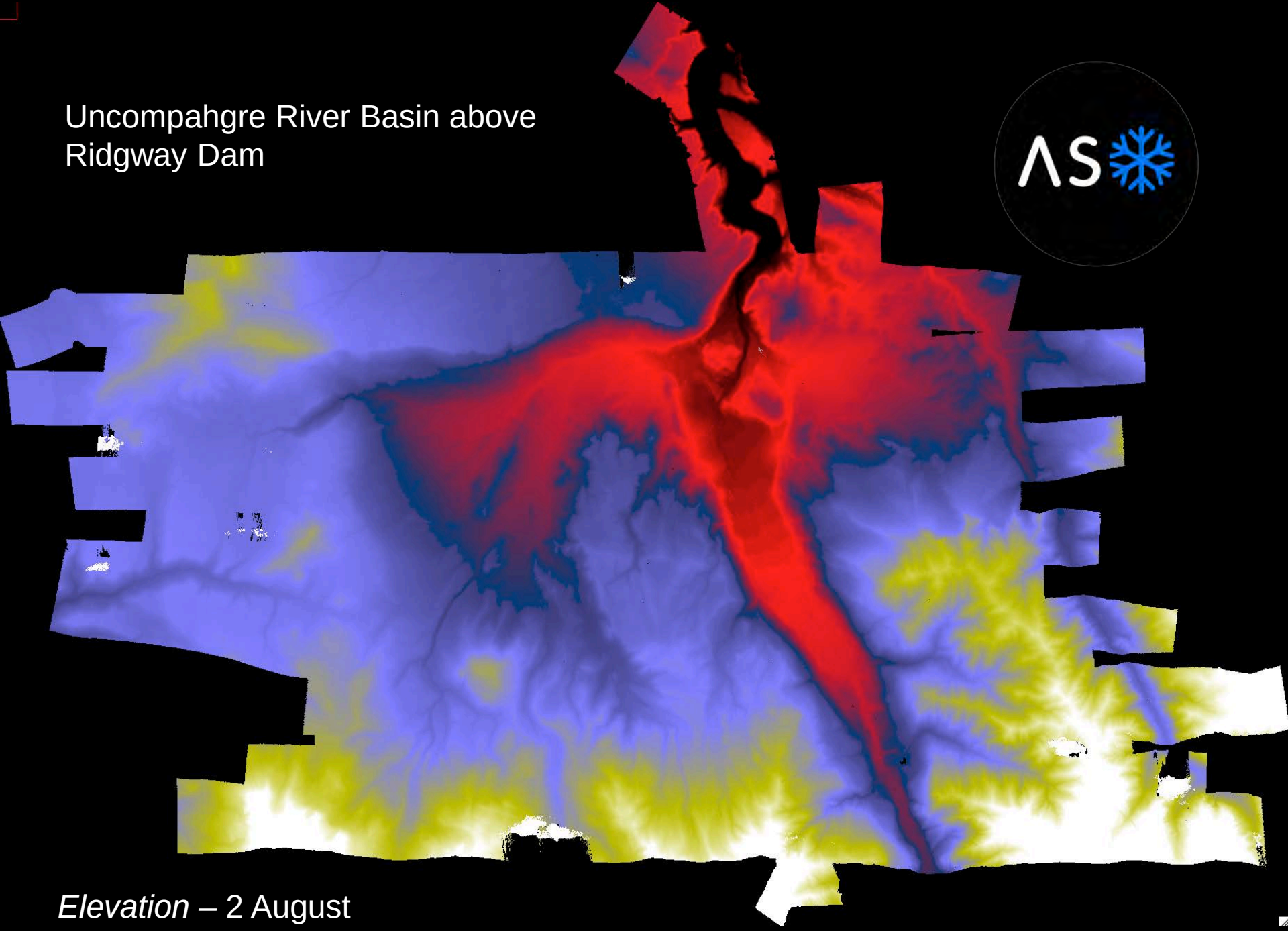




First ASO SWE and albedo retrievals

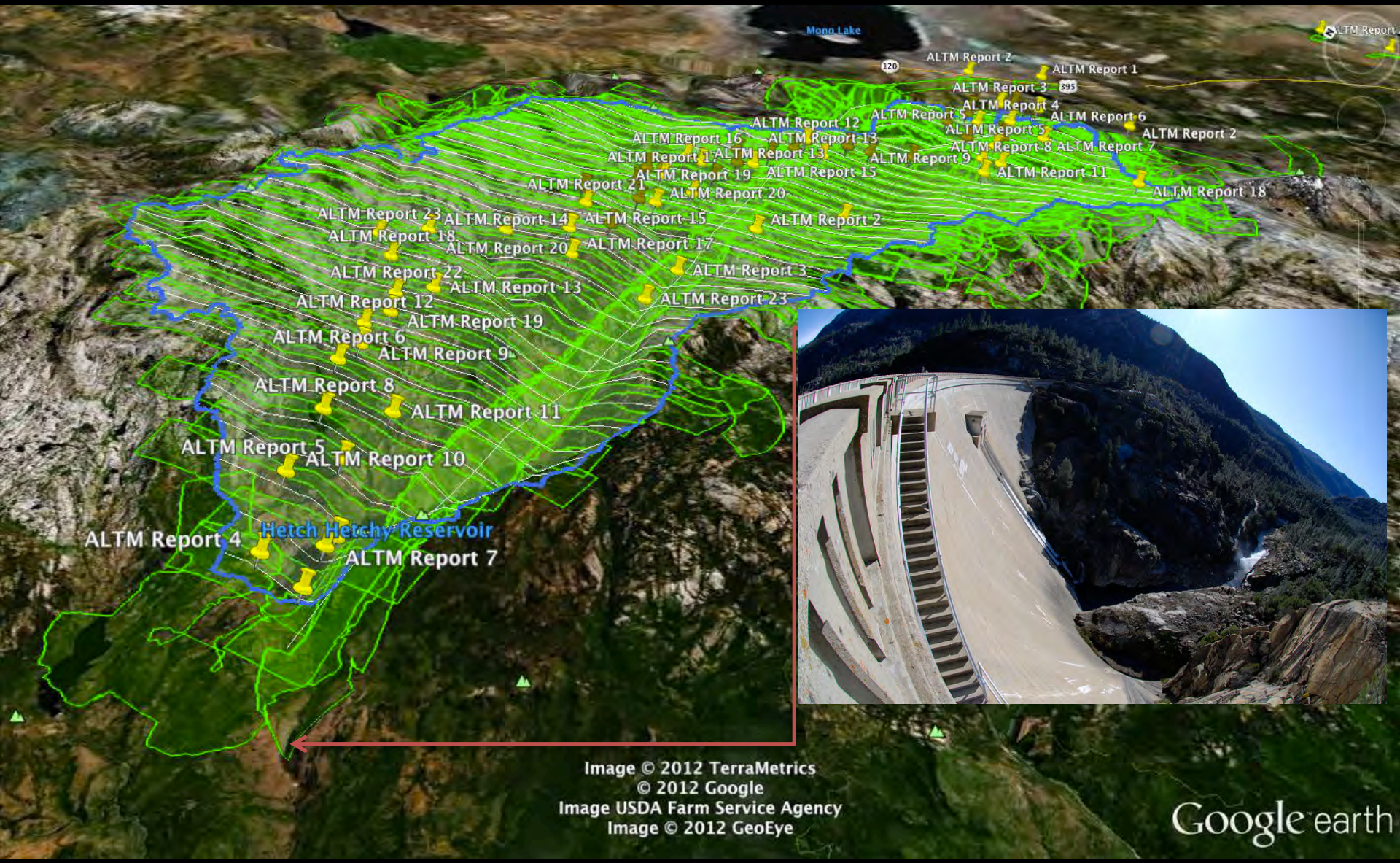


Uncompahgre River Basin above Ridgway Dam



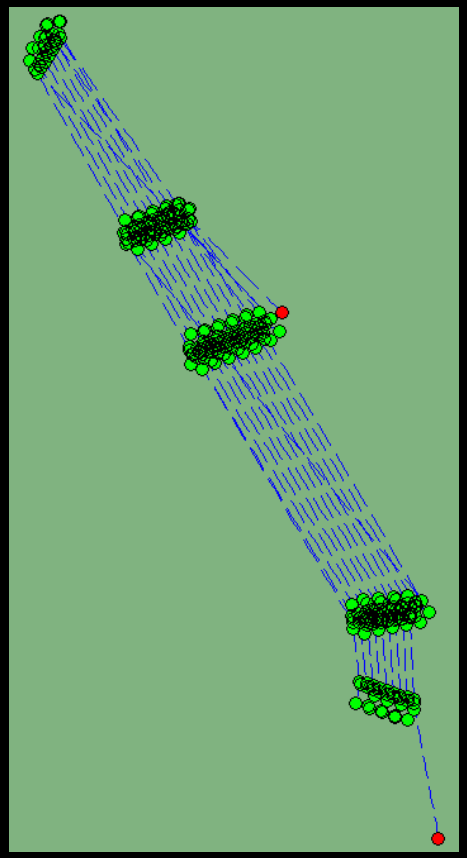
Elevation – 2 August 2012

Tuolumne River Basin – ASO snow-free



California Sierras

- Base airport:
  - Dryden/Edwards Air Force Base - California, USA
- Total Flight time:
  - 9 hrs 9 min
- Time taking data (includes turns):
  - 7 hrs 56 min
- Number of flights:
  - 2
- All airports used:
  - Dryden/Edwards Air Force Base - California, USA
  - Mammoth June Lakes (MMH) - Mammoth Lakes, California, USA
- Cost (@ $2,500 / hr)
  - $22,875



Partners in ASO

- NASA Jet Propulsion Laboratory/Caltech
- California Department of Water Resources
- City of San Francisco
- Turlock Irrigation District
- Bureau of Reclamation
- Colorado Basin River Forecast Center
- Inyo County
- UDSA
- Western Water Assessment RISA
- National Snow and Ice Data Center
- University of Washington
- University of California-Merced
- UCLA
- Analytical Imaging and Geophysics
- McGurk Hydrologic

Mammoth Lakes/Yosemite Airport

Mammoth Lakes/Yosemite Airport

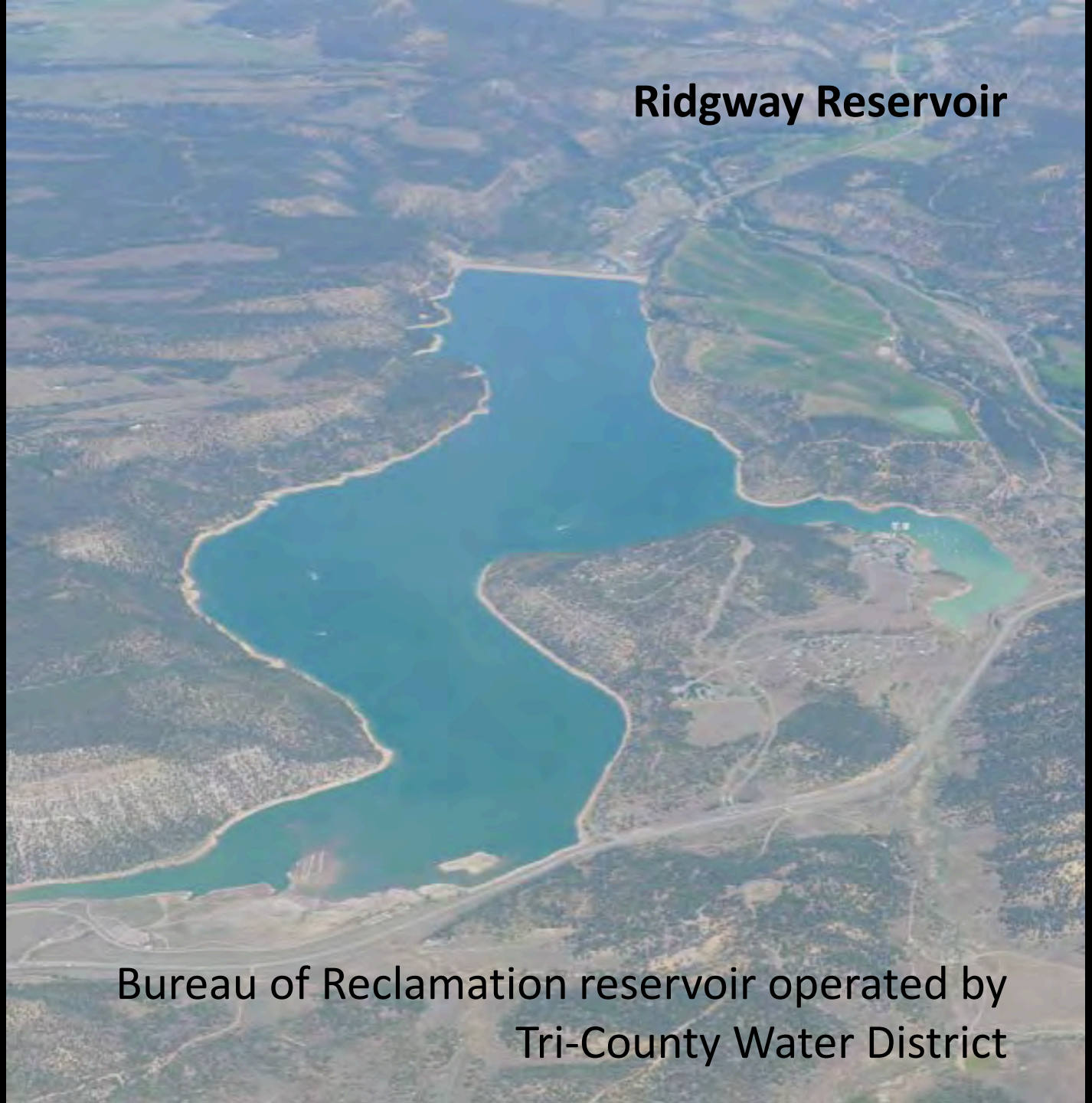
Tuolumne River Basin

Tuolumne River Basin


O’Shaughnessy Dam/Hetch Hetchy
August 7, 2012

Uncompahgre River Basin

Uncompahgre River Basin



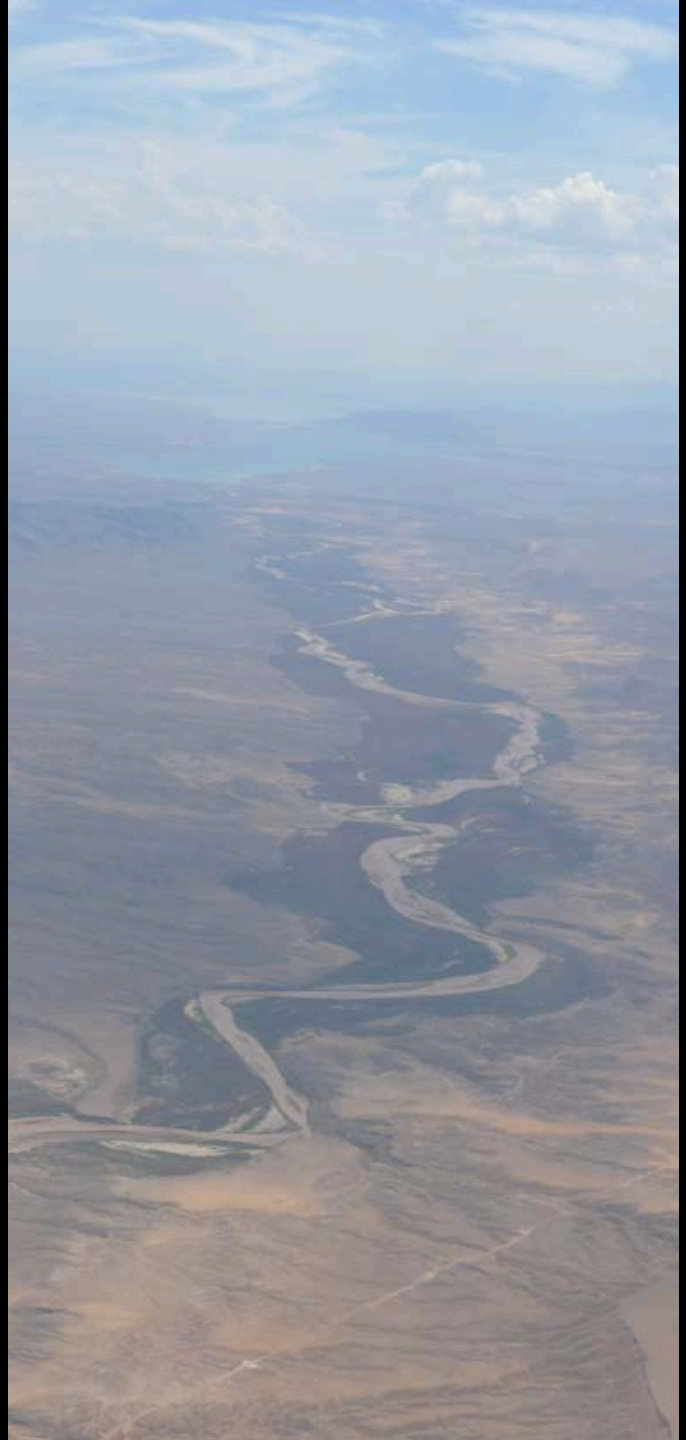
Bureau of Reclamation reservoir operated by
Tri-County Water District

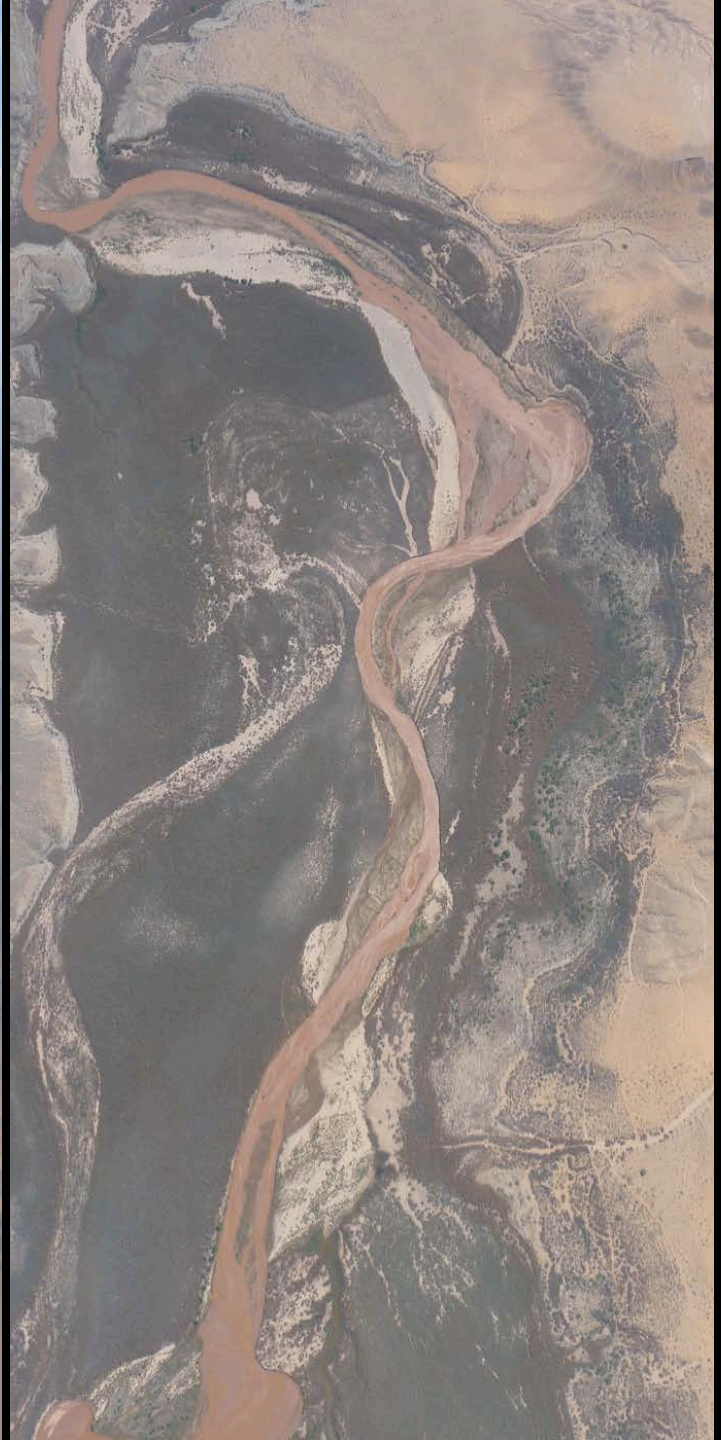
Virgin River flow into Lake Mead

Tamarisk assessment

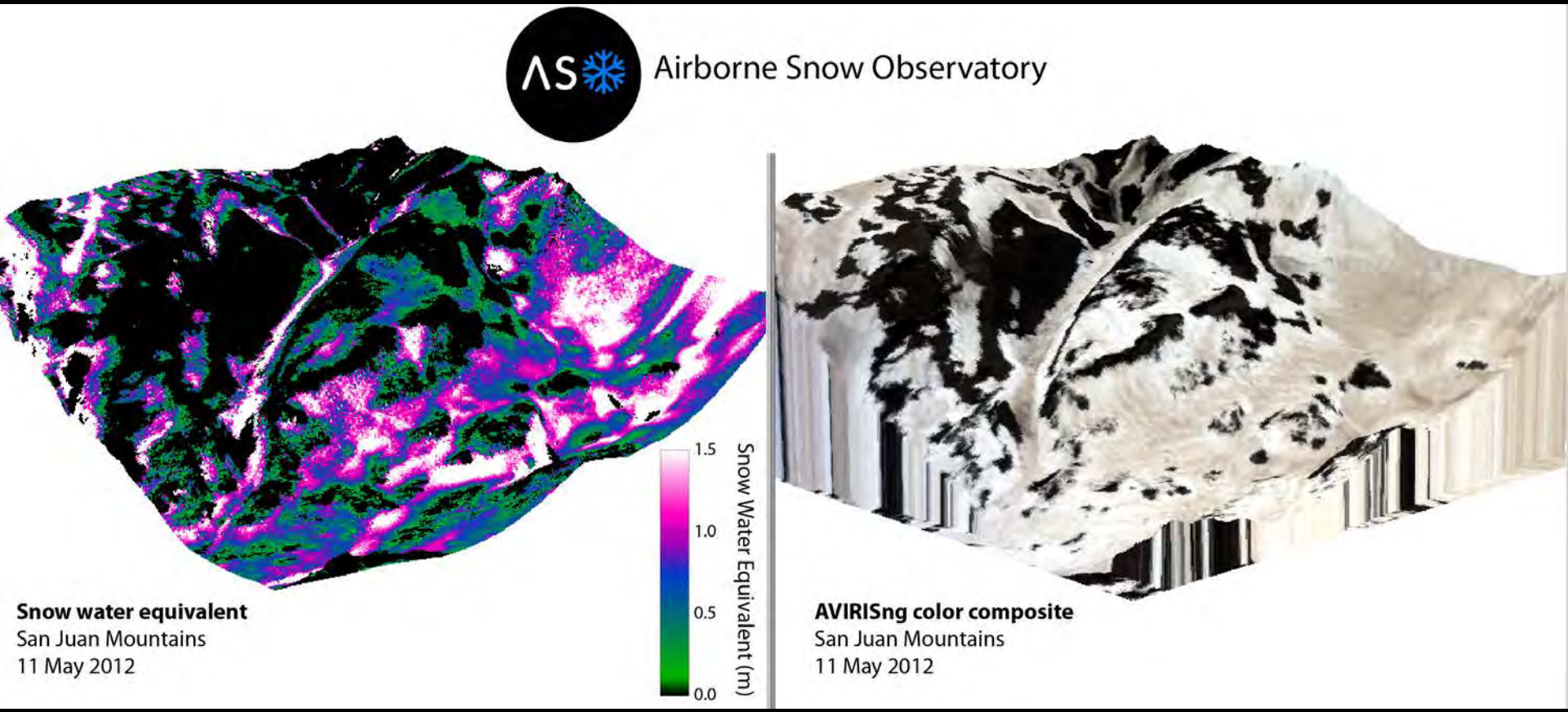
Hyperspectral analysis for species, biochemistry, liquid water content

LiDAR for vegetation structure and spatial distribution






3BC



What we will do with these products